

GROWING SOYBEANS IN CALIFORNIA

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The soybean has been widely extolled as a product of great economic value and many industrial uses. Probably for this reason, farmers are interested in its possibilities for California. According to the results of tests carried on during the past twenty-five years, however, there is little prospect of the soybean's becoming an important cash crop in this state. During this period numerous varieties have been tested, many of them in several localities; but seldom have the yields been high enough to be profitable.

During the same period also, many plantings have been made here by farmers, and occasionally very good yields have been reported. Since, however, no California farmer has continued to grow the crop, evidently the yield has never been high enough year after year to justify continued production. Results in the interior valleys are illustrated by the yields obtained at Davis from five of the most promising varieties in 1938 and 1943, as follows:

	Pounds per acre	
	1938	1943
Laredo	1,250	502
Virginia	1,100	460
Minsoy	790	212
Manchu	500	653
Harbesoy	390	445

Similar yields have been obtained at other points in the Sacramento and San Joaquin valleys. For a number of years several varieties were tested at the Kearney Park Station at Fresno, and the yields ranged mostly from less than 200 pounds per acre to 700 pounds. Only occasionally was a crop larger than 1,000 pounds per acre. The soybean finds its principal market in the oil mills, where it must compete with other oil seeds; and under normal conditions it will command a price not exceeding \$35 to \$40 per ton. Clearly, therefore, the average yield is not large enough to be profitable.

In a state with such varied soil and climatic conditions as California, one might reasonably suppose that there would be localities where the soybean would do well. According to limited tests carried on in various locations some years ago, such areas do exist. On the bottom lands along the lower Sacramento River, yields ap-

proached 2,500 pounds per acre. In Sonoma County, on unirrigated land, a few varieties yielded over a ton of seed per acre. Elsewhere, too, especially in valleys near the coast, similar results could doubtless be obtained. Whether yields of this magnitude would continue year after year, even in these more favored localities, could be determined only by extended trials. But most of these areas will also grow other crops, such as beans, sugar beets, or vegetables, which will produce a larger financial return per acre, and with which the soybean could not compete.

Although yields of seed in the general farming areas have been unsatisfactory, the soybean does have a definite place in our agriculture as forage and as a soil-improvement crop. With irrigation it will produce a good vegetative growth in most sections of the state. Its principal use as forage is in the form of hay. Properly handled it makes an excellent hay, highly palatable, with a protein content varying from 14 to over 17 per cent. It provides a good substitute for alfalfa and may be fitted into a short rotation or used to provide a high-protein feed, especially in times of scarcity. The more vigorous varieties will yield 2-1/2 to 3 tons per acre under normal conditions.

Soybeans are summer annuals, with a strictly determinate growth. That is, when the plant attains a definite size according to environment, it reaches maturity and dies. In this respect it differs from the cowpea, whose vegetative parts will remain green and continue to grow until killed by frost, even though the seed may have ripened. In the East, the soybean is sometimes grown with corn to be hogged off in the fall. But in California, because of its determinate growth and because the leaves drop off and the seed shatters badly when mature, it is less valuable for this purpose than the cowpea.

Lately there has also been some interest in edible soybeans, both for the market and for the home table. Although their production is limited by the same conditions as affect the oil varieties, with care one can raise enough to be a valuable addition to the family garden. In the more favorable locations production for market should also offer at least limited possibilities.

Most of the soybean varieties are erect and bushy, with a well-defined central stem branching more or less from the base. Some of the early-maturing plants are short and bushy; but in many

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of the late plants the central stem is tall and slender, sometimes almost viny and 5 feet or more in height. Usually, though not always, the early varieties are short and bushy, the later ones taller and more slender.

The whole plant is covered with a coarse hairy growth, or pubescence, usually tawny or grayish. The pods are borne in clusters in the axils of the leaves, so that under good conditions each leaf axil bears a cluster of a few to several pods, each pod containing two or three seeds. Flowering begins on the basal nodes and proceeds upward as the plant grows, so that well-developed pods may occur on the lower part of the plant while flowers are appearing on the upper nodes. Under favorable conditions the pods are retained until the plant is mature. At this stage the leaves dry up and drop off, leaving a stemmy bush heavily set with pods. In an arid climate, however, with low humidity and high temperature, such as prevails in most parts of California, the ripe pods shatter easily; and most of the lower pods will therefore disperse their seed before the upper pods are ripe.

The seed varies greatly in size. The color may range from almost white to black; straw yellow, olive green, and green are common. Seed color and size are varietal characteristics.

Varieties

Several hundred soybean varieties have been introduced into this country, mostly from Manchuria, Japan, and China. In addition, many have been developed by breeding and selection by the experiment stations in states where this crop is important. More than 100 have been grown experimentally in California. Although none of the varieties tried here have consistently yielded enough seed to be profitable, some have been more consistent in their seed production than others. Some also show decidedly superior character for forage.

For seed production alone, early or midseason varieties should be used, for only these are likely to reach full maturity. The more promising tested are Manchu, Illini, Harbesoy, Minsoy, Scioto, Virginia, and Laredo. The first five are midseason varieties and, when planted in April or early May, will reach maturity in September. The Virginia and Laredo require a longer growing period; they produce a more vigorous vegetative growth, but often also a fair seed crop. The seeds of Laredo are usually somewhat lower in oil than those of the other varieties.

For forage purposes the slender-stemmed, luxuriantly growing plants will ordinarily produce the highest yields. Of the varieties mentioned, Virginia, Laredo, and Manchu are the best, though any vigorous midseason variety may be used.

Experience with edible soybeans in California is insufficient to justify definite conclusions regarding the comparative yield or quality of varieties. Experience in the Central States indicates, however, that the following varieties

are of superior quality, especially as a green vegetable. Most of them may also be used dry. Giant Green is the earliest; Bansei and Kanro are early; Hokkaido, Jogun, and Willomi midseason; and Imperial, Higan, and Roskusun late. Most of the edible varieties shatter much more readily when mature than do the oil types, so that good yields of seed will probably be even more difficult to obtain, except in especially favorable localities.

Climatic and Soil Requirements

For its best development the soybean needs a moderate, even temperature, with a fair amount of humidity. Since it requires about the same conditions as Indian corn, its greatest production has been in the northern part of the cotton belt and the southern part of the corn belt. In recent years early varieties have been obtained, which mature satisfactorily in the northern tier of states. Southward in the cotton belt--that is, along the Gulf Coast--soybeans seldom develop normally. Although a good vegetative growth is usually obtained, the pods often fail to fill well, and the yield of seed is low. The same is true in the warmer parts of the Southwest, including the larger valleys of California. In these areas the yield is nearly always low, and often the crop is a complete failure. In California, besides the unfavorable climate, attacks by the red spider undoubtedly contribute to the low yield. The relative effect of climate and of red spider has not been determined.

Soybeans will grow on almost any soil, though the best growth will usually be obtained on deep, fertile, sandy loams or clay loams. Under California conditions they are less tolerant of drouth than are cowpeas. In the warmer valleys, irrigation is necessary to bring the crop through to maturity. Where temperatures are moderate and the soil is of good moisture-holding capacity, irrigation is not essential. Some years ago test plantings in Sonoma County, the Salinas Valley, and the lower Sacramento Delta did very well without irrigation. There are probably many limited areas where similar results could be obtained.

Culture

Soybean culture is essentially the same as the culture of any other bean. Since the crop is planted in the spring, it requires a well-prepared seedbed, with moisture enough at the planting depth to assure germination. If the land has been plowed in the fall or winter, and the rain has been sufficient to pack the surface, the seedbed can usually be prepared with surface-tillage implements, such as the disk and harrow. Spring-plowed land will require more careful preparation. Sometimes a preirrigation, after plowing, may be necessary to secure a good seedbed.

Soybeans tolerate low temperatures and cold soil somewhat better than common beans and can therefore, in most sections, be planted 10 to 14 days earlier. As a rule, however, one should

wait until the soil is fairly warm before planting, in order to insure a good stand. As with most summer crops, if the planting is too early, much of the seed is liable to rot. In the warmer sections the earliest date for planting soybeans lies between April 1 and April 15. In the cooler sections planting should be delayed until about May 1. Planting may be postponed or continued up to July, so that the soybeans may serve as a second crop, especially for forage. Experimentally the attempt was made to plant late enough to throw the blossoming period after the season of high temperatures, in order to obtain a better set of seed. The attempt, however, was not successful. If the seed was planted late enough to encourage a better filling of the pods, it failed to ripen before the growth was checked by cold weather.

For seed or for food, soybeans are normally planted in rows 2-1/2 to 3 feet apart, with the plants 3 to 6 inches apart in the row. In the East some soybeans for seed have been broadcast at the rate of 75 to 90 pounds per acre. Usually, however, one can obtain just as good or better yields by planting in rows; this procedure requires less seed and permits a better control of weeds. According to the tests, even for hay or forage, row planting can give just as good production as broadcast planting, and the product is cleaner.

The depth of planting varies with the soil. On light-textured soils the seed may be placed 2 to 2-1/2 inches deep, whereas on the heavy soils more shallow planting should be used. To secure germination, the seed must, of course, be put in moist soil. If the surface mulch is several inches thick, the seed may have to be planted too deep for optimum emergence. To overcome this difficulty, attach crowders to the planter shoe to force the dry soil aside; adjust them to run 1 to 2 inches shallower than the planter shoe. The shoe can then drop the seed in moist soil without burying it too deep. A bean or corn planter fitted with the proper plates for handling seed of the variety being used is the best equipment for putting in the crop.

The seed of the soybean is short-lived and usually does not remain viable for longer than two or three years. One must therefore use only fresh seed or seed of known germination.

Another precaution that assures optimum growth is to inoculate the seed before planting. The nodule-forming organisms are specific for the soybean; and unless they are provided artificially, nodulation will not take place. On fertile soil, high in nitrogen, the organisms are normally not necessary for good growth; but on average soil they will greatly improve the results.

Although soybeans are usually reported as more drouth resistant than many summer legumes, they are not sufficiently so to grow well or to reach maturity without irrigation in the warmer sections of California. Some water must be artificially provided. Usually two to three irrigations,

the later being given about the time the pods start to form, will be sufficient. When the crop is being grown for forage, one can obtain the maximum yield only by watering often enough to keep the plants always in a lush condition. Experience has also shown that red-spider damage is likely to be less severe on a crop provided with ample moisture than on a crop that lacks water. On river-bottom soils, or in certain valleys near the coast where temperatures are more moderate, a crop can be grown without irrigation; but even in some of these areas better yields, especially of forage, will be obtained if some water can be applied.

Harvesting

In the states where soybeans are grown extensively, the crop is usually allowed to stand in the field until fully ripe, at which time most or all of the leaves have dropped off. It is then either harvested with a combine or cut with a binder, and threshed with an ordinary grain or bean thresher. Sometimes it is cut and windrowed with a mower or reaper, then threshed in the usual way. Whatever harvesting equipment is used, there must be special lifter guards on the cutting bar to pick up the prostrate branches from the field; otherwise considerable seed is lost.

In California any of these methods of harvesting may be used under some conditions. Since, however, shattering is usually more severe in our arid climate, one should cut while the crop is still somewhat green and cure it in rather large cocks before threshing. Cutting with a windrower, or with a mower that has a windrowing attachment, is probably best. As soon as cut, the beans should be put into rather large cocks, allowed to dry, and then threshed in the usual manner.

For hay purposes, soybeans may be cut from the time the pods begin to form until the pods begin to mature, but before the leaves fall. Hay mowed at the earlier stage will have a protein content of 16 to 18 per cent. At the later stage the protein content will probably be below 15 per cent, though the total yield of hay will be somewhat increased. When the crop is badly attacked by red spider, as often happens in California, one may have to harvest rather early, even at the expense of yield. In any case, the plants should be cut before shedding their leaves.

The hay crop can be cut with an ordinary mower equipped with a windrowing attachment. Since in a heavy crop the growth may be somewhat tangled, a vetch bar will work better than a regular mower bar. The mower bar will do as well, however, if the dividing board is replaced with a metal runner, which will enable the sickle to cut the growth free. After being mowed, the hay should be left in the windrow only long enough to wilt. It should then be placed in cocks to complete the curing.

When the edible soybean is raised as a green vegetable, its pods are ready for picking as soon as they start to change color. From any one

planting the picking period is usually only about 2 weeks; after this the pods and seeds become too tough.

The ripe, edible soybeans are harvested exactly like the seed crops of other varieties. Since the edibles shatter more easily, they should be harvested at the earliest possible moment, and handled carefully and quickly.

Enemies

The soybean, like other crops, is subject to various diseases and pests. In California its three most serious enemies at present are rabbits, red spider, and nematodes.

Of all our field crops, soybeans appear to be the favored food plant of the jack rabbit. On large fields a considerable area around the edges may be eaten, and a campaign of rabbit extermination may be necessary. A small planting may be completely destroyed as fast as the plants come up. Here the best protection is a fence of chicken wire, which need not be substantially constructed nor be over 2 feet high. If the fence remains in place until the plants are well established and have several permanent leaves, the period of danger will be past.

Red spider is nearly always present on soybeans grown in California. Often the attack is severe enough to defoliate the plants before the pods are set, and the result is an almost complete seed failure. This pest is probably one reason for the low yields commonly obtained. It can be controlled by repeated dusting with sulfur; but such treatment is too expensive for field plantings, and is feasible only for small gardens.

When soybeans are being grown for hay, the crop should be cut before the leaves start to dry up and drop, even though the plants may not yet have reached their optimum stage of growth.

Soybeans are susceptible to nematodes and should not be planted on land badly infested with this pest. The only exception is the variety Laredo, which is somewhat resistant and can be grown for forage if the infestation is not too severe.

Of the many other diseases and insects that attack soybeans, the majority have not yet caused much trouble in California. If, however, our soybean production is increased to any extent, new problems will probably arise in some areas.